U. S. TREASURY DEPARTMENT
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PUBLIC HEALTH SERVICE
THOMAS PARRAN, *Surgeon General*

GROUND-WATER SUPPLIES

Progress Report of the Committee on Ground-Water Supplies Conference of State Sanitary Engineers, 1936

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GROUND-WATER SUPPLIES

Progress Report of the Committee on Ground-Water Supplies, Conference of State Sanitary Engineers, 1936

Members of the Committee: H. A. WHITTAKER (*Chairman*), F. R. SHAW, C. A. HOLMQUIST, H. A. KROEZE, O. E. BROWNELL. Consultants: A. G. FIELDER, L. C. FRANK

General Principles

A ground-water supply should be properly located and the installation properly constructed and operated in order that the supply be safeguarded against contamination.

The following general principles should be followed regardless of the type of supply under consideration:

1. The site for the source should be adequately drained on the surface, should not be subject to flooding, should be reasonably far removed from areas in which underground constructions, such as tunnels, sewers, and conduits, are located, and should be where the earth formations are satisfactory. Nearby tunnels, sewers, and conduits may be a means of contaminating the underground water. The built-up portions of large cities, where the construction of building foundations or other underground work may have disturbed the earth formations, are not suitable locations for a ground-water supply. Sites should be avoided which are near industrial developments that have offensive, poisonous, or dangerous liquid wastes that may reach the ground water. Sites near sinkholes and abandoned wells that receive waste are also unsatisfactory.

2. The system should be properly designed and should be constructed of suitable materials. To be avoided are concave surfaces, such as in pump bases, depressions in floors or adjacent earth surfaces, or walled-in, unfilled spaces which may form receptacles where wastes may accumulate and become a menace to the supply.

3. Careful, intelligent operation of a supply is necessary to obtain and maintain the results which are normally expected from a properly located and correctly constructed water-supply system.

4. There should be no physical connection between water-supply systems that are safe for domestic use and those that are or may at times become unsafe for domestic use. There should be no provision for such a connection or arrangement by which unsafe water may be discharged or drawn into a safe water-supply system.

5. There should be no physical connection between an unsafe water supply and any other water supply.

Recommended Minimum Sanitary Standards for Location, Construction, and Protection of Ground-Water Supplies

A. Ground-Water Supplies, Untreated

SECTION I. Location.

1. *Site.*

In selecting a site or determining its suitability the following items should be considered:

(*a*) Mode of occurrence of ground water—whether water is obtained from zones near the water table or from artesian zones.

(*b*) Nature of earth formations with respect to the freedom with which water can move toward the well, and also with respect to the character of soil and geological formations at the surface, such as porosity, uniformity, size of material, stratifications, rock solution channels, faults, and similar conditions which may affect the underground water.

(*c*) Degree and direction of slope of the land surface and the water table with reference to the source of supply.

(*d*) Rate of pumping used or anticipated.

(*e*) Distances from sources of contamination and adequacy of structural features to confine contamination and to prevent its escape into the soil or vicinity of the well.

(*a*) *Mode of occurrence.*—The protection of ground-water supplies from contamination is in a large measure dependent upon the mode of occurrence of the ground water. Under conditions where water is taken from just under the water table and not under pressure, surface waters or other liquid wastes are free to percolate downward through the interstices of the rocks and reach the water table or upper surface of the zone of saturation. The greatest measure of protection from pollution of ground-water supplies occurring under these conditions is afforded by having the well located as far as possible from all surface sources of contamination. Furthermore, considerable protection is secured by constructing and casing the well so that the supply is drawn from as far below the water table as possible.

Considerable protection to the supply is furnished by the presence of beds of impervious material between the surface and the water table. Obviously such material as, for example, a stratum of impervious clay, will interrupt the downward percolation of pollution and prevent it from reaching the main body of ground water supplying the well.

Ground water occurring under artesian conditions is confined under hydrostatic pressure by means of more or less impervious beds; and because of the pressure of the water, such supplies are the best protected as far as surface contamination in the vicinity of the well is concerned.

(*b*) *Nature of earth formations.*—The freedom with which water may pass through a formation determines largely the ability of the formation to transmit pollution to ground-water supplies. Those formations which are impervious or nearly so, such as clay, silt, fine sand, and stiff clay mixtures, provide the greatest protection against the transmission of contamination. Other formations which are close grained, such as sand or soft sandstone, provide great filtering action and are next in order of safety in preventing the transmission of contamination. On the other hand, formations whose interstices are in the form of solution channels, joints, and fissures provide little filtering action to water passing through them and, moreover, may allow the water to move rapidly. Contamination may, as a result, be carried long distances from the original source of pollution. Various common rocks are listed below in the general order of most dangerous to least dangerous with respect to their ability to transmit contamination:

Limestone, especially of cavernous type, in which water moves largely in solution channels.

Broken lava rock.

Gravel, clean and coarse.

Brittle rocks that yield water chiefly from joints and fissures. (Includes such rocks as granite, gneiss, schist, slate, quartzite, and hard sandstones that yield water from joints and fissures.)

Poorly assorted alluvium, till, and clayey materials. (This group will not generally yield much water, but in many sections where these materials lie near the surface they yield small supplies to dug wells. Because the water may be transmitted largely through small crevices, these materials, though otherwise largely impervious, do not in general provide the protection afforded by the following ground.)

Sand, soft sandstone, and mixtures of sand and gravel.

Clay, silt, and stiff clay mixtures.

(*c*) *Slope of land surface and water table.*—The slope of the land surface with reference to the location of a well, spring, or infiltration gallery is important, because it governs the direction and rate of movement of surface waters which are generally contaminated and should be diverted from the vicinity of the well, spring, or gallery. Contamination, after it penetrates the zone of saturation, moves in the direction of the slope of the water table. The direction of the slope of the water table is, in most places, similar to the prevailing slope of the land surface, except where conditions have been modified by drainage, pumping, or other agencies. The slope of the water table may be determined by careful measurements of the depth to water in surrounding wells and referring such measurements to the same datum. Water supplies drawing upon ground water should, therefore, always be located as far as possible up the slope of the water table with reference to sources of contamination.

(*d*) *Rate of pumping.*—In water-table wells, pumping creates a cone of depression in the water table in the vicinity of pumped wells, and water is drawn toward the well throughout the zone of influence. Hence, even though a source of supply is located up the slope of the water table with reference to a source of contamination, such supply may be adversely affected by reversing the normal direction of movement of the ground water. Zones of influence may vary from a few feet in diameter to several hundred feet or more, depending upon the rate of pumping and the character of the water-bearing material. Furthermore, pumping, by increasing the slope of the water table, accelerates the rate of movement of the ground water, and, hence, contamination that might otherwise be rendered harmless by the filtering action occurring during normal movement of the ground water may be drawn into the well and issue with the pumped water. Under artesian conditions cones of depression are developed in the pressure surface, but protection is afforded by the confining bed.

(*e*) *Distances to sources of contamination.*—Every ground-water supply such as a well, spring, or infiltration system, and all appurtenances thereto should be located at a sufficient distance from any privy, cesspool, sewer, soil pipe or pipe through which sewage may back up, or from any other possible source of pollution, and in such a manner as to prevent the contamination of the water by either underground seepage or channels, or by surface drainage. The horizontal distance from any such possible source of contamination should not be less than 50 feet, but this distance should be used only where ideal conditions indicate it to be sufficient, and greater distances should be required where local conditions demand such. Coarse gravel, limestone, disintegrated rock, or other porous material that will permit rapid flow of water through it are not suitable materials around a source of supply. When such formations are encountered, more suitable sites should be obtained. If satisfactory sites are not available, adequate treatment of the water should be provided.

The location of ground-water supplies on a side hill or at the foot of a hill where sewers, cesspools, privies, or other sources of pollution are situated on the slope above and within 300 feet should be avoided, if possible. Sites in ravines where surface-water flows may be concentrated should also be avoided.

2. *Flooding and drainage.*

The top of every pump-room floor, pump platform, or cover of a ground-water supply should not be less than 2 feet above the highest known water level or the controlled high-water level of any lake, pond, stream, or any other body of surface water, the waters of which at the highest level would approach within 50 feet, measured horizontally, of such ground-water supply. The earth surfaces should be sloped to drain away from or divert surface water around the well or pump house, and be so graded as to prevent the accumula-

tion and retention of surface water within a distance of 50 feet from the well. Filling should be protected from erosion by rip-rap where necessary.

3. *Toilets, floor drains, etc.*

Toilets, sewers, floor drains, soil pipes, main drains, or other pipes which are connected directly to a storm or sanitary sewer, or through which water or sewage from any source may back up, should not be located nearer than 50 feet, horizontally, to any well, spring, infiltration system, pumping apparatus, suction main, air pipe, air compressor, filter, or other feature of any ground-water supply. In special cases, where it is impossible or not practical to obtain a 50-foot distance, special construction to provide additional safeguards is necessary. In no case shall such fixtures or piping be nearer than 30 feet to a well. All such sewers, drains, and pipes, or parts thereof, which must be more than 30 feet and which are less than 40 feet, horizontally, from any such water supply feature, should be constructed of extra heavy cast-iron pipe with tested watertight leaded joints. In this zone, joints should be further protected against leakage by a substantial slip-over sleeve extending at least 6 inches from each side of the joint. The annular space between the pipe and the sleeve shall be filled with asphalt or material such as sewer-joint compound, or closed with rubber gaskets. All such sewers as lie between 40 and 50 feet of the ground-water supply may be of extra heavy cast-iron pipe with tested watertight leaded joints. Toilets, sewers, soil pipes, or drains should not be located on the first floor directly above the pump-room floor, or where leakage therefrom can reach any source of water supply or pump room.

Floor drains constructed of cast-iron pipe with leaded joints may be located as close as 2 feet to a ground-water supply, provided they do not connect to a storm or sanitary sewer, and provided they discharge only to the ground surface or to a gravel pocket which is well removed from contact with sewage or other waste. The cast-iron pipe should be carried to a point at least 4 feet outside the building walls and connected to other suitable pipe which discharges at least 30 feet from the ground-water supply.

4. *Pits.*

Well heads, well casings, pumps, pumping machinery, valve boxes connected with a suction pipe, or exposed suction pipe should not be located in any pit, room, or space extending below ground level, or in any room or space above ground which is walled in or otherwise inclosed so that it does not have free drainage by gravity to the surface of the ground. Any pump room or such walled-in space above ground should be provided with a doorway and door at least 6 square feet in area, which opens outward and extends to the floor.

Pump rooms, in addition to having a floor drain and door that opens outward, should be provided with a relief panel set in the wall or

door at floor level. This panel should be made of paper or other material which will give way under contact or pressure of water and permit the drainage of the floor onto the surface of the ground.

All that space below ground surface lying within a distance of 10 feet of any well, spring, infiltration system, suction pipe, pump room, or like feature of any ground-water supply should be filled with compact earth.

SEC. II. **Minimum Depths of Ground-Water Supplies.**

Wells, infiltration systems, and springs should be constructed to a depth sufficient to insure that safe water can be obtained. The minimum depth at which safe water can be obtained will vary with different soil formations and surrounding conditions. In no case should water be drawn from a depth of less than 10 feet. Ground-water supplies should be protected against the entrance of surface water or shallow ground water and should exclude undesirable water strata which may be encountered.

When the water enters the inclosing structure of springs or infiltration systems at points less than 10 feet below ground surface, they may be protected by placing earth filling over the area involved (50 feet around) to provide the necessary depth of 10 feet of earth over the points of flow. If this is impracticable, adequate treatment should be provided, in which case the standards which apply are set forth under "Treated Underground Water Supplies."

SEC. III. **Well Casings and Curbing.**

1. *Construction and use.*

Every well should have an outside, water-tight casing extending preferably to at least 10 feet below the water table, but in no case less than 10 feet below ground surface and to such further depth as may be necessary, depending upon the character of the underground formations. The casing should be seated securely in an impervious formation wherever possible. Where an impervious formation or tight confining bed does not occur at the well site, the protection to the supply is increased by extending the casing as far as practicable below the water table and, wherever possible, at least 10 feet below the lowest minimum seasonal stage. The casing, when it extends into a pump room, should project at least 7 inches above the pump-room floor. A separate inside pipe for conducting the water from the well, commonly known as a drop pipe, should be provided. The outside casing should never be used as a suction pipe or a working barrel for pump plungers. In a hand-pump installation, the casing should extend at least 3 inches above the general level of the platform. This distance includes as much of the casing as will extend above the pedestal into the base of the pump, and the remainder of projecting casing will be included in the height of the pedestal.

The annular space between the excavation line and the outside of the casing or curbing should be filled in such a manner as to prevent surface water or shallow ground water from running directly down the outside of the casing or curbing and thence into the well or into the water-bearing strata. When such an annular space occurs, it should be filled with thoroughly compacted puddle clay, mortar, or cement grout. All material should be flushed or tamped into place in such a manner as to reduce voids to a minimum. The material should be free from organic matter and coarse rock.

2. *Drilled wells.*

This type of well should be cased with iron pipe and constructed as described in section III, paragraph 1. At depths more than 20 feet, where the well passes through solid rock in which there is no danger of caving or inflow of contamination, mud, silt, or sand, the casing may be omitted. The pipe should be standard wrought steel black pipe, or its equal. In any event, the well should be cased to a depth sufficient to exclude all undesirable water strata that may be encountered.

3. *Dug and bored wells.*

The walls of dug and bored wells should be water-tight to a depth below the natural ground surface of at least 10 feet, and preferably more, depending upon the soil and subsoil conditions. This may be accomplished by the use of the following types of construction:

(*a*) *Concrete walls.*—The concrete shall be composed of 1 part portland cement, 2 parts sand, and 4 parts gravel by volume. For each sack of cement there should be added 10 pounds of dehydrated lime or 4 pounds of volcanic ash or like material for waterproofing. The wall must be not less than 6 inches thick, properly reinforced and free from honeycombing. Wherever practical, the entire concrete wall should be poured at one operation, and in no case should there be a construction joint within 10 feet of the natural surface of the ground. A 2-inch keyway should be formed in the top of the casing in which the cover slab will engage when poured later. Brick or wall tile make a convenient interior form for pouring the concrete and may be left in place.

(*b*) *Vitrified tile pipe* (*sewer pipe*) *or concrete pipe.*—Vitrified tile or concrete pipe are not satisfactory as casing unless surrounded by at least 6 inches of portland-cement concrete, as described in paragraph 3 (*a*). The customary joint in these pipes cannot be depended upon to be watertight.

(*c*) *Single brick walls.*—Single brick walls are not satisfactory unless surrounded by a 6-inch reinforced portland-cement concrete wall, as described in paragraph 3 (*a*).

(*d*) *Double brick walls.*—A double-layer brick wall will be satisfactory provided a dense brick is used and an inch-thick layer of 1 to 1

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portland-cement mortar is applied either to the exterior of the brick wall or between the two rings of brick. Both the vertical and horizontal joints in the two rings of brick should be staggered. The brick should be common brick, compact in texture, hard burned entirely through, sound and uniform in quality, and free from lumps and cracks.

(*e*) *Metal casing.*—A durable watertight metal casing is satisfactory if installed in accordance with section III, paragraph 1. The casing should be standard steel black pipe or its equal; riveted culvert pipe is not satisfactory.

SEC. IV. Hand Pump Installations.

1. *Pumps.*

(*a*) Hand pumps should be of the force type with cylinders placed below or near the water level so that priming will not be necessary. Direct-lift, chain-lift, and bucket pumps are not satisfactory.

(*b*) The pump base should be of the solid one-piece recessed type, cast integrally with or threaded to the pump column or stand. Two-piece (split) open-work and adjustable bases are not satisfactory.

(*c*) The pump base should be of sufficient diameter and depth to permit at least a 6-inch wall casing or 6-inch pipe sleeve used in the top of a dug well to extend at least 1 inch above the pedestal on which the pump base will rest.

(*d*) Provisions should be made for fastening the pump base rigidly to the pedestal and well top to prevent movement of the pump. This may be accomplished by securing the pump base by means of bolts imbedded in the concrete, or by the use of a flange or pump stand secured to the casing top. A pump brace should be used to provide stability to the pump setting. Suitable gaskets should be used between the pump base and the pedestal or the flange, as the case may be.

(*e*) The pump head should be designed to exclude contamination by hands, dust, rain, birds, flies, and similar sources, from the water chamber of the pump head. Force pumps are reasonably protected against such contamination by the stuffing box which surrounds the pump rod. Ordinary lift pumps with a slotted pump-head top are open to contamination and should not be used.

(*f*) The pump spout should be of the closed, downward-directed type. The open type commonly used on "pitcher pumps" should not be used. Suitable types of hand pumps and pump settings as described in this section are illustrated in figures 1 and 2.

(*g*) Pumping equipment can be obtained which makes the use of pits or sub-ground-level pump rooms unnecessary. Standard parts can be purchased and assembled in such a way as to accomplish the same results.

With double tubular wells, i. e., wells which have a casing and a drop pipe, pump cylinders and "weep holes" in the drop pipe, or

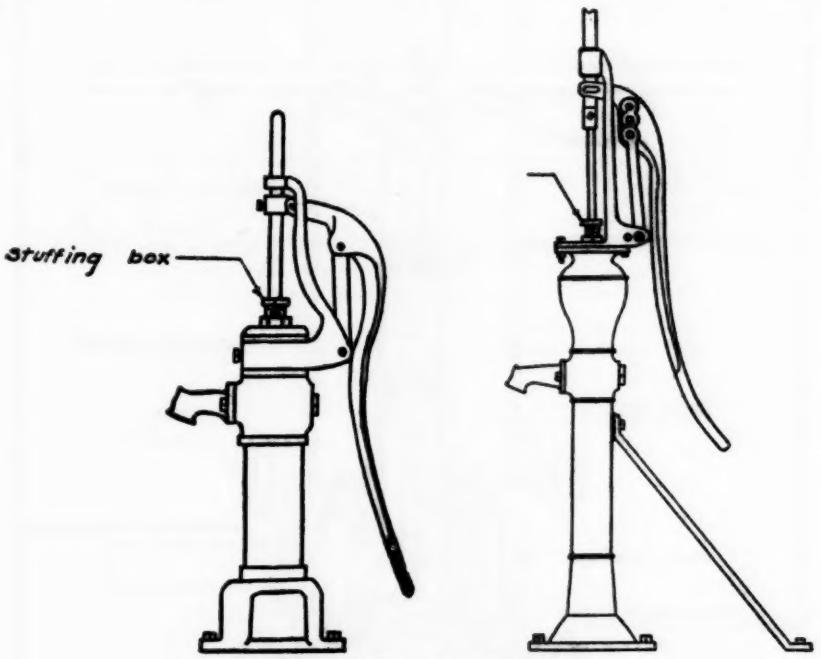
bleeders, are located inside the well casing so that pump drainage can run back into the well. With such an installation, a frost pit is not necessary.

A method of providing an underground discharge without the use of a pit below ground surface is shown in figures 3 and 4.

(*h*) Hand-operated types of pumps which require priming should not be used.

2. *The platform or cover.*

(*a*) The well top or platform should be a watertight, reinforced portland-cement concrete slab of a minimum thickness of 4 inches,



FIGURES 1 and 2.—Proper types of pump head.

extending at least 2 feet from the well casing in all directions. The slab should rest on compact earth. The concrete should be sloped from the well casing to the edge of the slab. The surface of the slab at its outer edges should be 4 inches above the surrounding ground surface. The pedestal to which the pump base is to be fastened should be poured or cast with the slab or not later than 30 minutes after that portion of the slab has been poured. The concrete should be tamped thoroughly around the well casing and the pipe sleeve. A properly constructed drilled well is illustrated in figure 5.

(*b*) The cover slab of a dug well should be of portland-cement concrete of such thickness and so reinforced as to carry the load which will be imposed upon it, but in no case less than 4 inches thick. The top of the casing wall and the 2-inch keyway therein should be coated

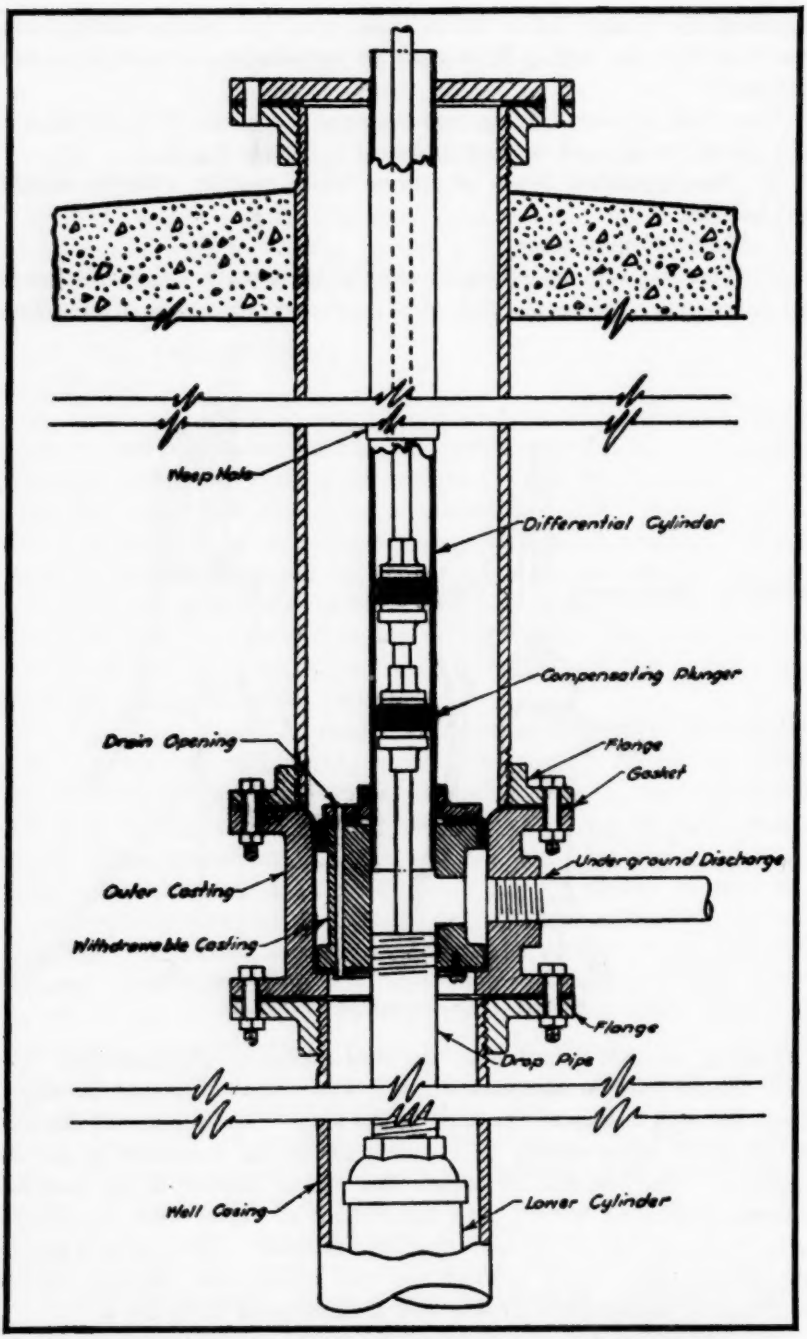


FIGURE 3.—Properly constructed drilled well, showing underground discharge arrangement.

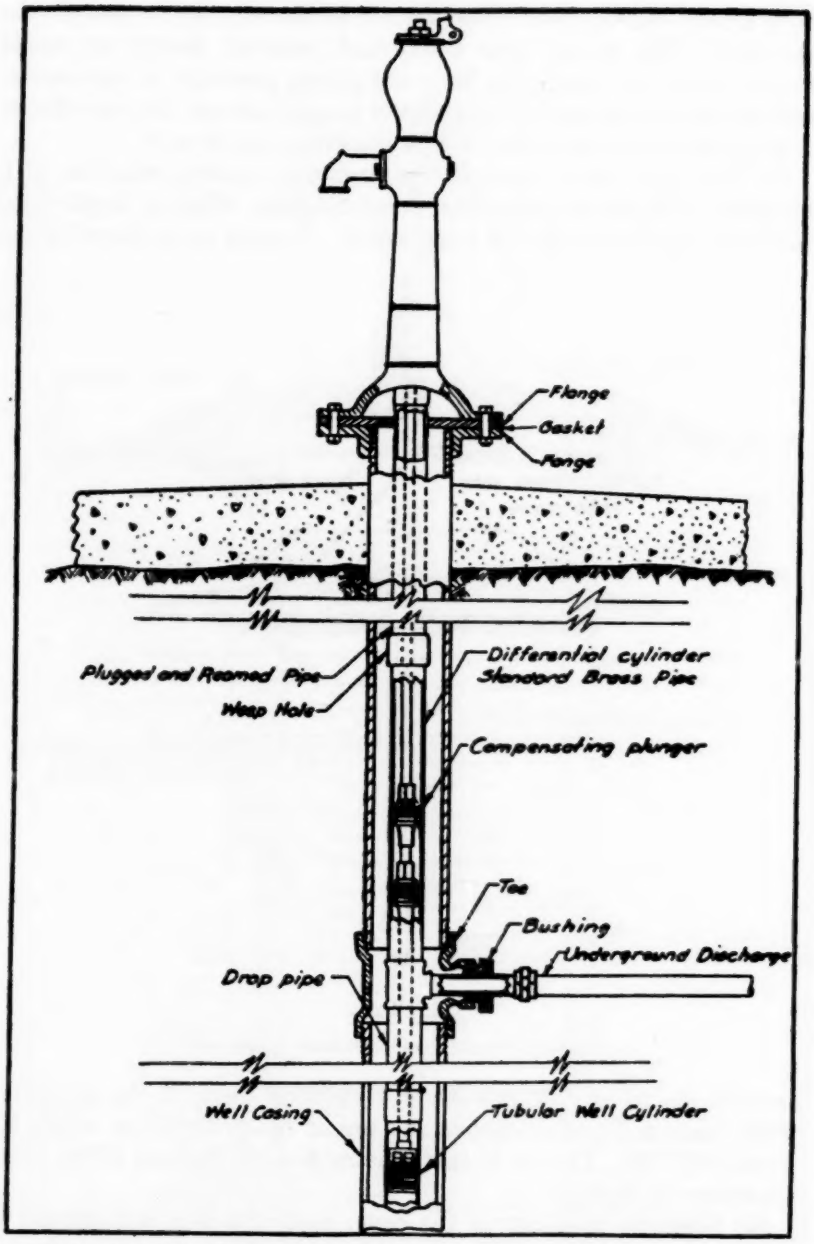


FIGURE 4.—Drilled well using standard tee and underground arrangement to discharge water below frost line.

with a neat cement grout progressively as the concrete is placed over the wall. The proper pipe sleeve and pedestal should be placed firmly where it is desired to have the pump, generally at the center, and the concrete should be thoroughly tamped around the pipe sleeve. A properly constructed dug well is illustrated in figure 6.

(*c*) The pipe sleeve creating the drop-pipe opening shall be of a diameter sufficient to admit the pump cylinder, which is larger than the drop pipe for which it is constructed. It shall be so placed in the

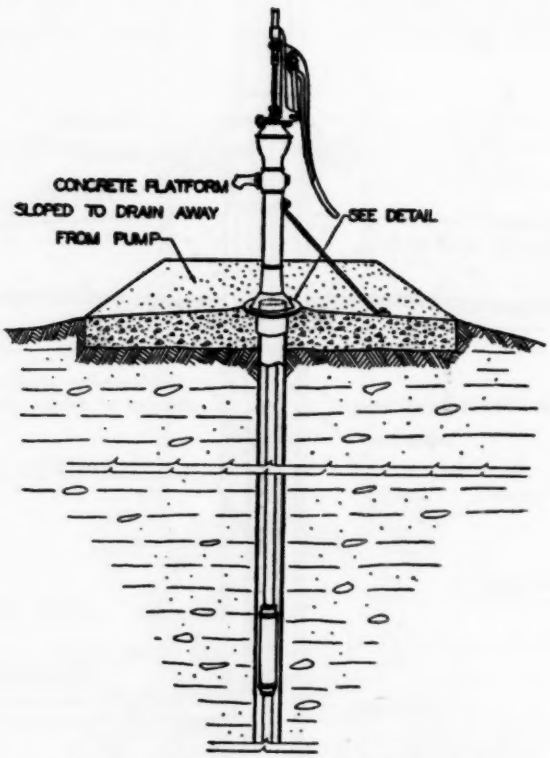


FIGURE 5.—Properly constructed drilled or bored well.

concrete as to extend ultimately 1 inch, or more, if the particular pump base will permit, above the top of the pedestal on which the pump will rest. Details of this construction at the base of the pump are shown in figure 7.

(*d*) Manhole openings in the cover slab of a dug well should be curbed to a height of not less than 6 inches above the top surface of the cover slab. This curb may be built into the manhole frame where a cast-iron frame is cast in the concrete slab, or the curb may be of concrete, provided it is poured with the slab or within 30 minutes after that portion of the slab is poured. The manhole cover must be watertight and should overlap the curbing and extend downward

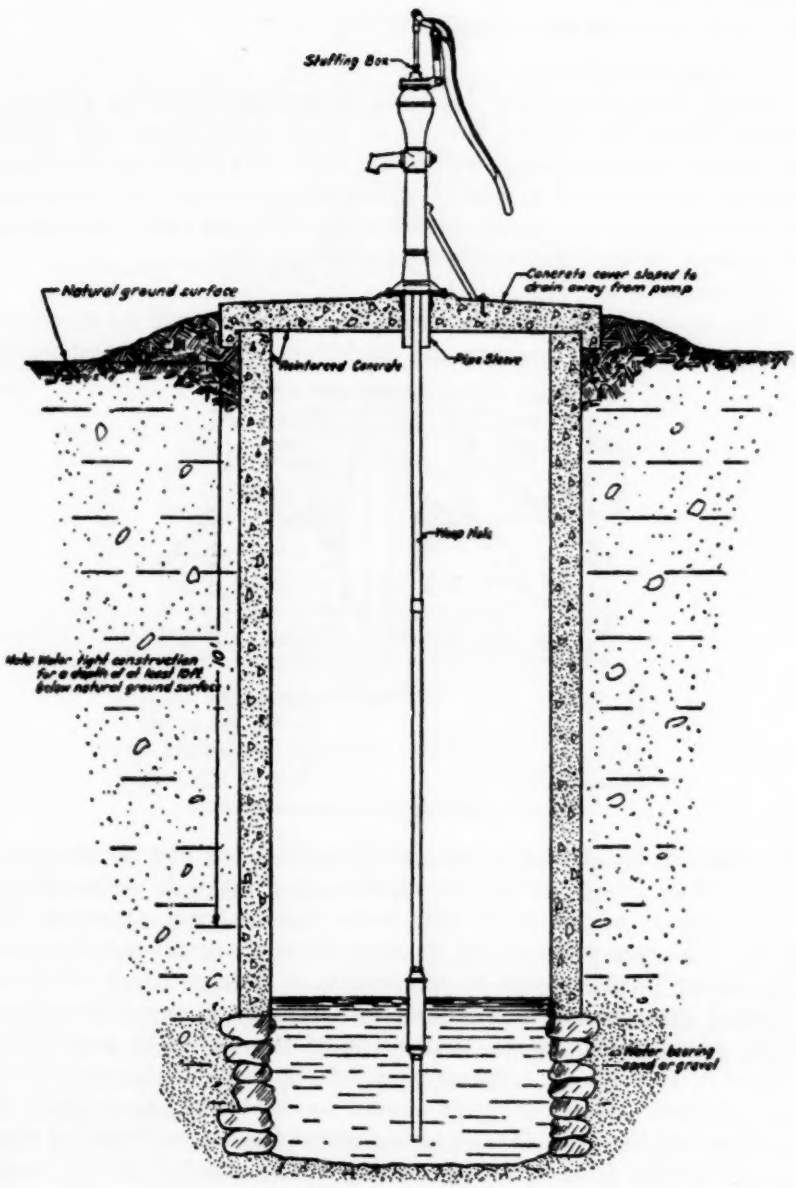

Stuffing Box
Natural ground surface
Concrete cover sloped to drain away from pump
Reinforced Concrete
Pipe Sleeve
Weep Hole
Make water tight construction for a depth of at least 10ft below natural ground surface
10
Water bearing sand or gravel

FIGURE 6.—Properly constructed dug well.

around it at least 2 inches. Provision should be made for locking the manhole cover. Approved types of manholes, covers, and locks are shown in figure 8.

SEC. V. **Power-Pump Installations.**

1. *Pump-room floors.*

Every pump-room floor should be watertight, should be at least 6 inches above the ground surface at the outside edges, and should slope away from the pump, well casing, or suction pipe in all directions. Pump houses located on side-hill slopes should have at least 50 percent of the floor area above ground level. The door and relief panel should be located on that part of the floor above ground.

2. *Pumps.*

The discharge tee, together with the valves, should be above the pump-room floor. Underground discharges, except for hand pumps

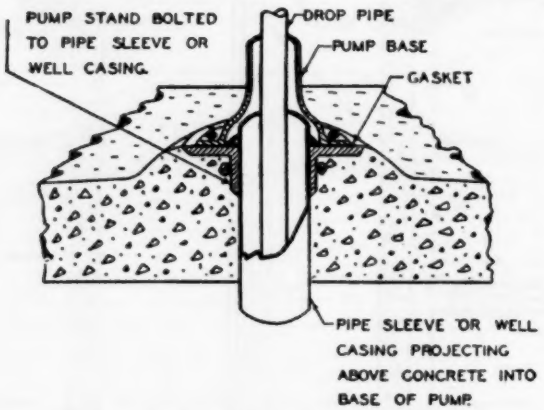

PUMP STAND BOLTED TO PIPE SLEEVE OR WELL CASING
DROP PIPE
PUMP BASE
GASKET
PIPE SLEEVE OR WELL CASING PROJECTING ABOVE CONCRETE INTO BASE OF PUMP

FIGURE 7.—Detail of construction at base of pump.

or those equipped with a jack, are unsatisfactory and should not be used. Any pump placed immediately over the well casing or pipe sleeve should have a water-tight metal base to form a cover for the well. The base plate should be recessed on the under side to permit the casing or pipe sleeve to extend into it at least 1 inch above the level of the concrete foundation, thus forming an overlapping cover with edges projecting below the top of the casing or pipe sleeve. When it is necessary, a separate watertight cover of this type should be provided. Good drainage should be established away from the well and off the base plate so as to prevent the accumulation of waste water at this point. Rubber tubing is not satisfactory for waste-water connections around or over the base of the pump. If an air-relief vent is necessary, it should be screened and protected against the possibility of contaminating material entering the vent. The open end of the vent should be at least 24 inches above the floor. A vertical vent covered by an overlapping hood may be used. Metal tubing

should be used for vents, waste, and lubricating water, and water-level gages.

Figure 9 illustrates proper installation of a vertical turbine pump for drilled well. Figure 10 shows properly constructed dug well and pump room.

Figure 11 suggests a method of pumping water from a number of isolated wells where the surface of the water in the wells is below the suction lift of the pumps on the ground surface.

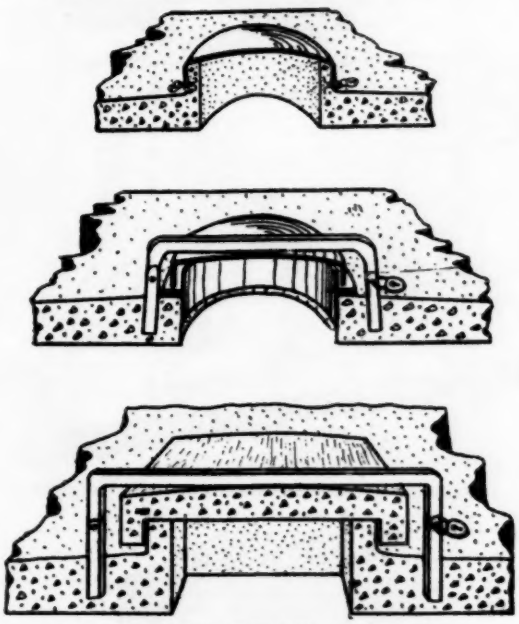


FIGURE 8.—Manhole covers of the overlapping type.

Figure 12a illustrates a small power pump for a drilled well situated in an insulated pump house.

3. *Water lubrication.*

Pump bearings situated in any well below the pump-room floor should be lubricated with water taken from within the well, from the reservoir or distribution system supplied with water from the original source of water supply, or from another supply which meets with the requirements of the State board of health.

4. *Suction pipes.*

All suction piping, such as that leading from detached wells or reservoirs, when laid underground should be at least 10 feet below the surface of the ground, or special protection should be provided. The surface contamination is generally retained in the upper zone of the earth, and filtration may be insufficient to prevent the contamination from reaching the suction pipe. All that part of any suction pipe within 10 feet of and below the surface of the ground

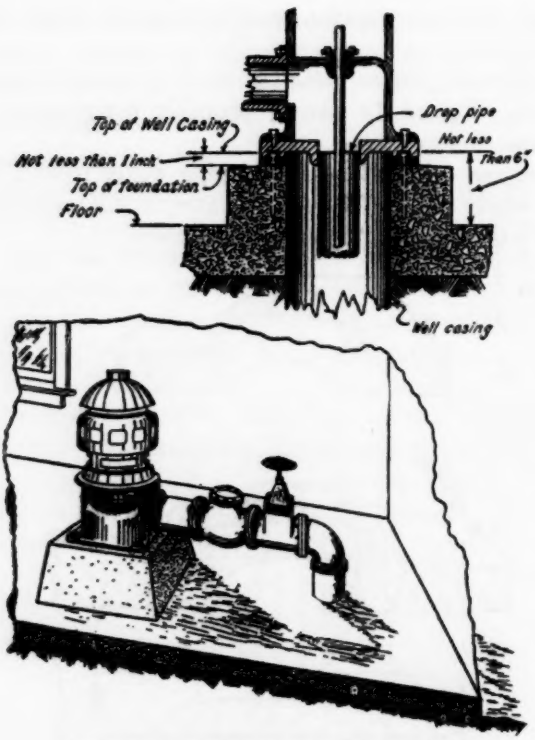


FIGURE 9.—Proper installation of a vertical turbine pump.

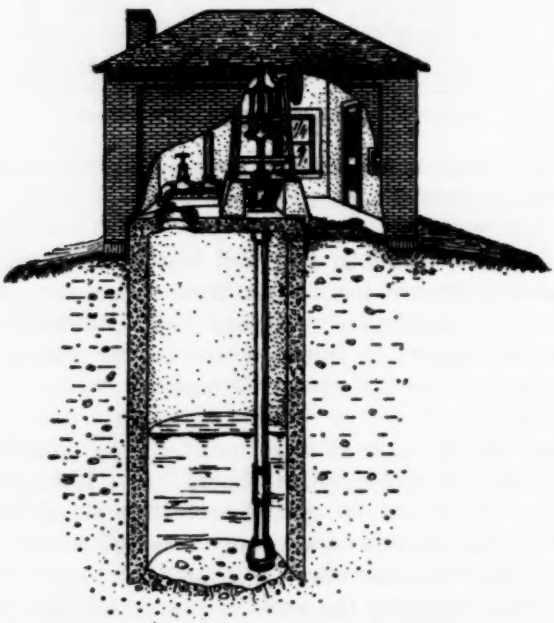


FIGURE 10.—Properly constructed dug well and pump room.

should be surrounded by a watertight outer casing pipe. In the case of a suction pipe rising to a pump-house, the outer casing should extend at least 13 inches above the ground and 7 inches above a platform or floor surface. The annular opening between the protective casing pipe and the suction pipe should be properly covered at

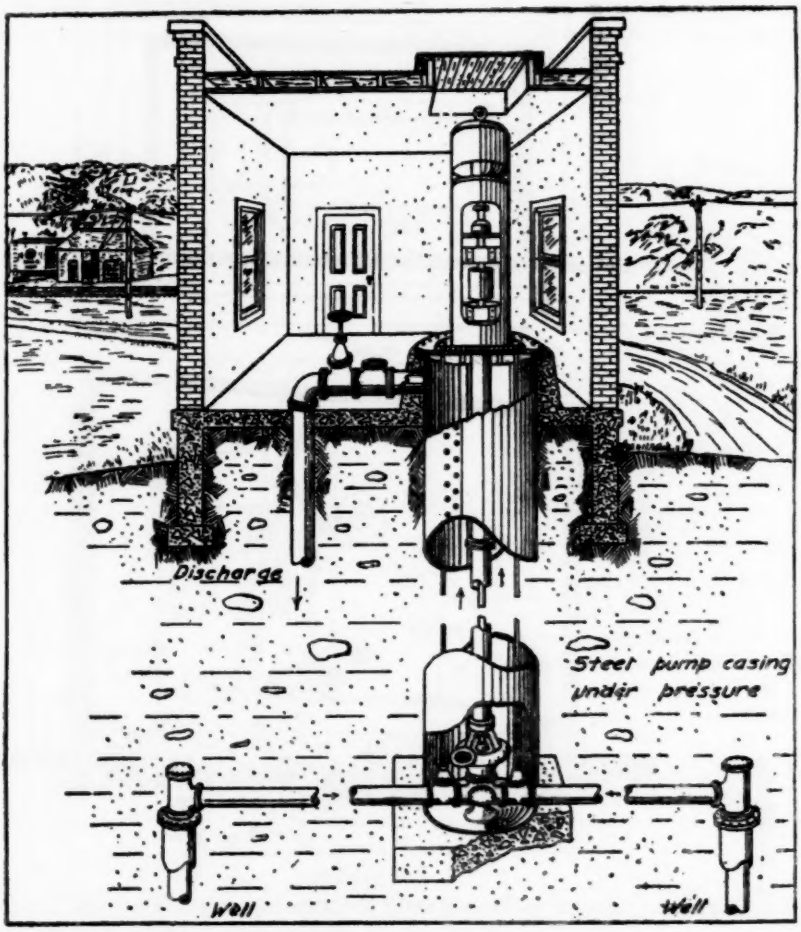


FIGURE 11.—Method of pumping water from two or more isolated wells where the water surface in the wells is below the suction lift of pumps located on the ground surface.

the top in a manner similar to that used for covering the top of a drilled well. Figures 13, 14, and 15 illustrate satisfactory covers. The annular space between the suction pipe and the protective casing should be filled entirely with some suitable material which will prevent the accumulation of any leakage in considerable quantity inside the casing around the suction pipe. Sand and asphalt compounds or cement grout may be used for this purpose. Horizontal suction pipes which are located underground within 10 feet of the surface

may be protected by placing sufficient earth filling on the surface to provide a total of 10 feet of covering over the piping. By placing the pumps directly over the well, sump, or reservoir, or locating the suction pipe above ground in a frost box, where necessary, the hazards

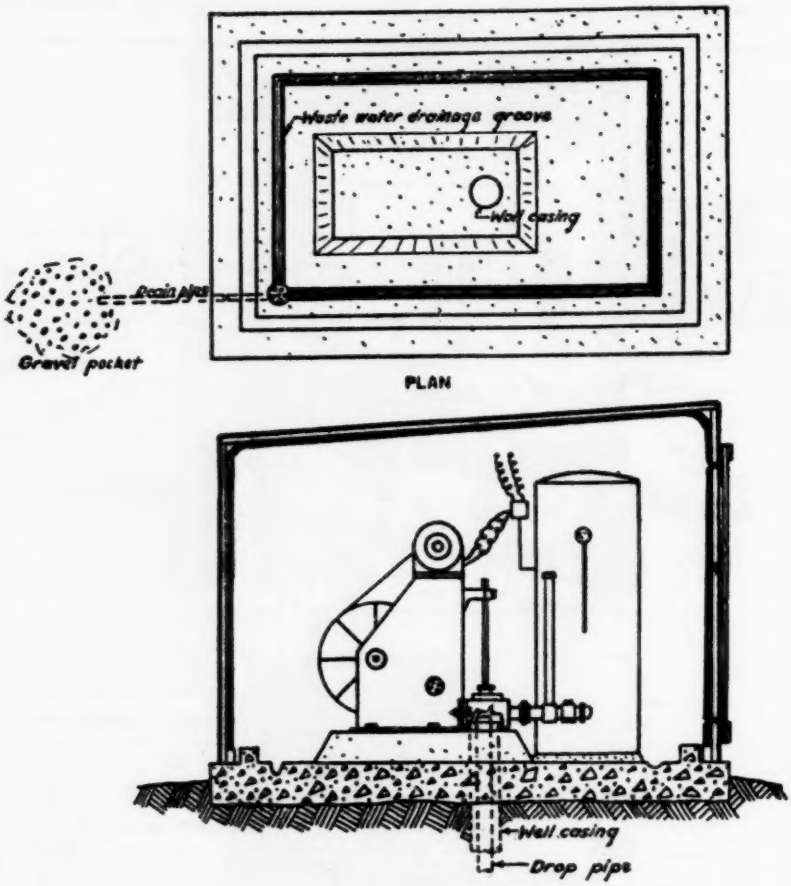


FIGURE 12a.—Plan and section of insulated pump house.

of a suction pipe located less than 10 feet below ground level will be avoided.

5. *Priming.*

Water for priming pumps on any water system should be taken directly from the reservoir or distribution system which is supplied with water from the original source of the water supply, or from another supply which meets the requirements of the State board of health. Priming devices should be so constructed that they will not expose the water to dust, drippings, or other sources of contamination.

6. *Cooling water.*

Water used for cooling parts of engines, air compressors, pumps, or other equipment should not be returned to any part of the water system.

7. *Valve boxes.*

Every valve box on a buried suction pipe line should project at least 6 inches above the floor if in a building or room, and at least 12

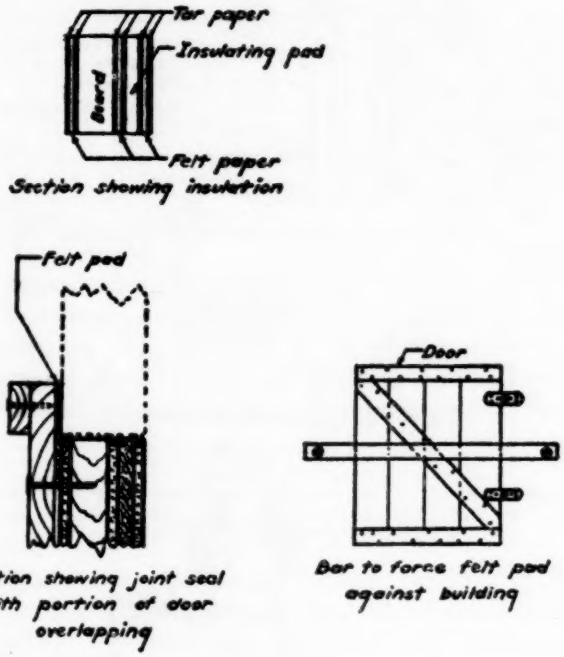


FIGURE 12b.—Details of insulated pump house.

inches above the ground surface if not enclosed in a building. The top of the box should be provided with a cover of the same overlapping type as hereinbefore prescribed for manholes.

This arrangement is illustrated in figure 16.

8. *Airlift systems.*

Where water is pumped by means of an air-lift system, the air compressors should be placed in a room as free as possible from dust, and at such an elevation that flooding will be made impossible. The compressed air from the compressor should be discharged into an air storage tank so designed as to extract from the compressed air any oil or oil mist which may have entered during its passage through

the compressor. In order to minimize the possibilities of oil contamination, the use of oil traps, filters, and as little oil as will provide satisfactory operation of the compressor is recommended.

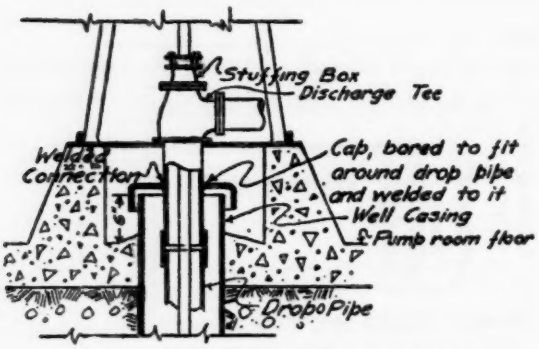


FIGURE 13.—Casing head construction for drilled well.

The air intake of any air-lift system or mechanical aerating apparatus should be at least 6 feet above the floor surface if indoors and 10 feet above the ground if out of doors. The air intake should be so constructed as to prevent the entrance of birds, insects, rain, snow, or other contaminating material and to minimize the entrance of dust.

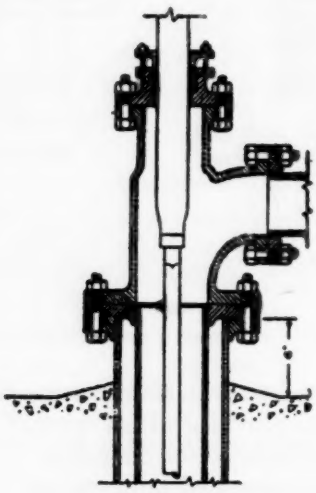


FIGURE 14.—Details of casing head connection with drop pipe.

Air intakes for aerators or for pressure tanks should be located and protected as hereinbefore outlined. Locations which are dusty or poorly ventilated should be avoided. A suitable type of air inlet is shown in figures 17 and 18.

B. Ground-water Supplies, Treated

Treatment of underground waters may become necessary where safe sources are not available or when changes in sanitary conditions

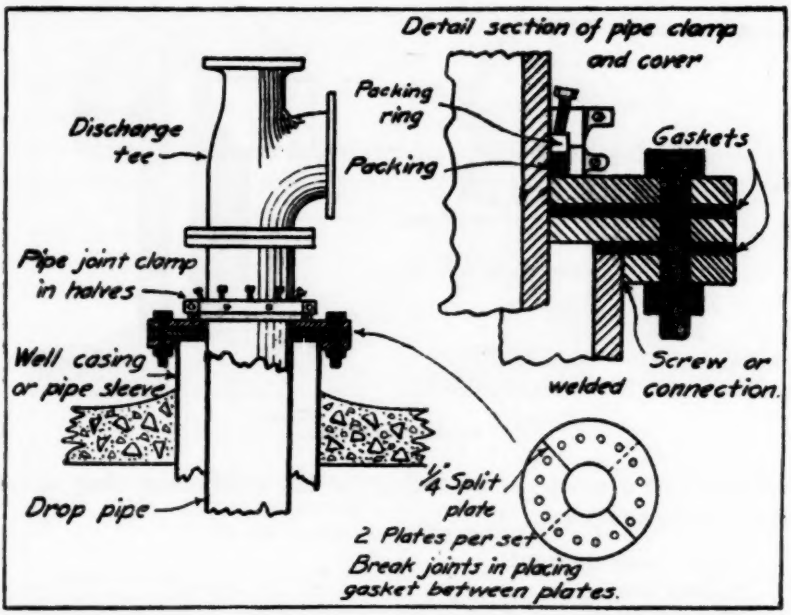


FIGURE 15.—Arrangement of closing annular space between drop pipe and casing head or pipe sleeve by means of a removable stuffing box and overlapping cap.

occur in existing supplies. It is recommended, however, that in order to minimize the hazards and the possibility of overloading the treatment plant, and in order that the treatment may be reserved as a

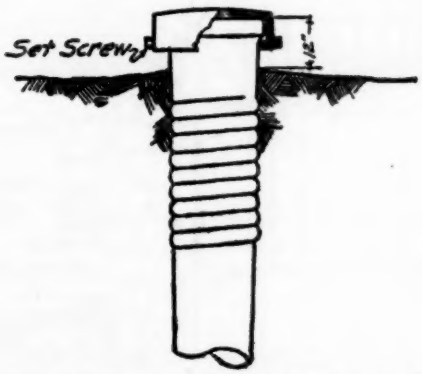


FIGURE 16.—Properly installed valve box on suction line.

factor of safety as far as possible, the principles and requirements set forth in the section for untreated underground waters be complied with as far as possible, even though treatment is employed. Treat-

ment of underground waters should not be considered as substitute for proper location, construction, and operation, but rather as a safe-

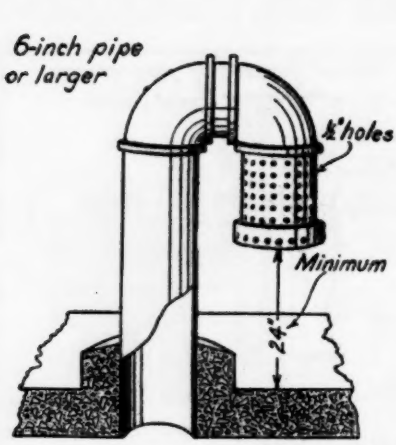


FIGURE 17.

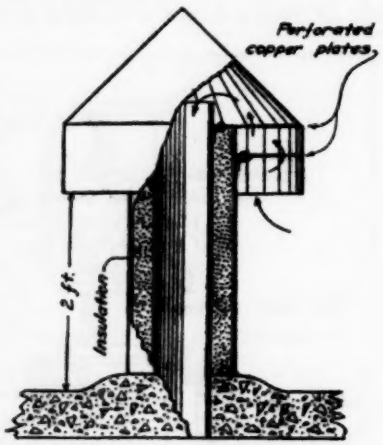


FIGURE 18.

Suitable types of vents.

guard and as a means of providing for the deficiencies that cannot otherwise be overcome.

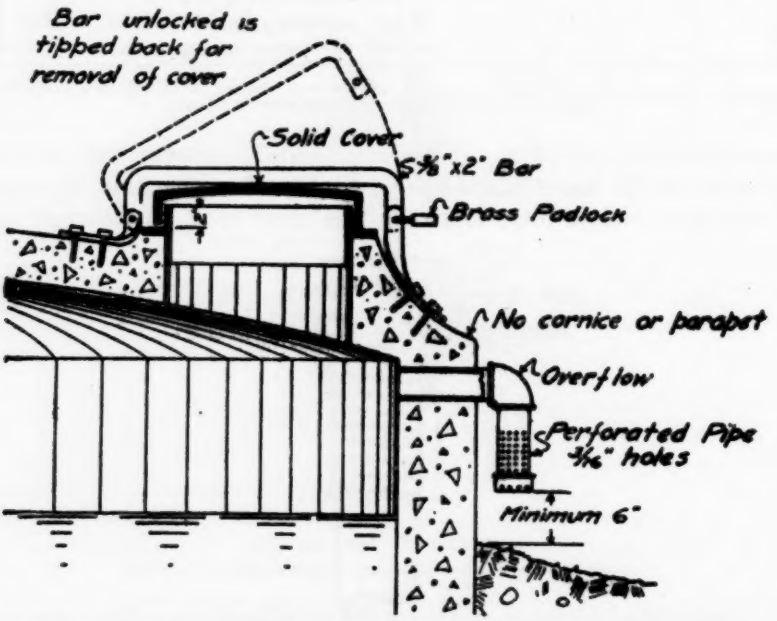


FIGURE 19.—Correct type of manhole opening and cover for dug well or surface storage reservoir.

Treatment should be employed when there is a possibility of contamination reaching the water underground and rendering it unsafe for domestic use. Treatment, however, should not be used perma-

nently to overcome a defect of construction which can and should be corrected.

Where a treated underground supply is in use and an equally good untreated supply can be obtained, the treated supply should be considered as temporary, to be used only until the untreated supply can be made available. Treatment may then be used as an additional safeguard.

SECTION I. Site.

On a site where the earth formations permit the rapid movement of ground water, such as coarse gravel, fissured rock, solution channels,

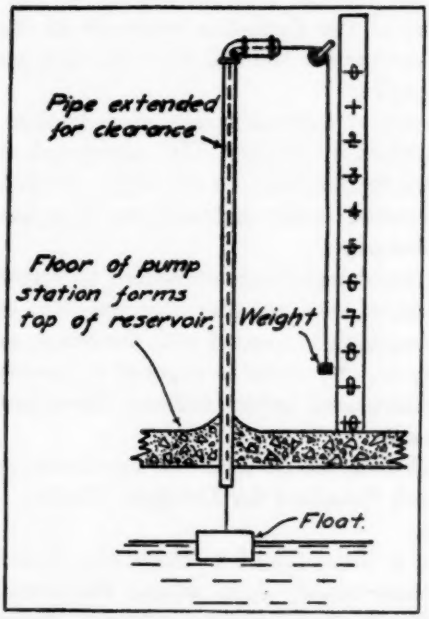


FIGURE 20.—Method of preventing contamination of water in reservoirs through float indicator openings.

and similar formations, the ground water cannot be considered safe, and adequate treatment should be provided.

SEC. II. Construction.

As far as possible, systems of treated underground water supplies should be constructed in accordance with the requirements governing untreated underground water supplies.

SEC. III. Loading and Treatment.

The degree of contamination of underground waters divides the required treatment into two general groups: (1) Chlorination and storage only, and (2) sedimentation, filtration, and chlorination.

Where the underground water is of good physical quality and only a possible or intermittent low degree of contamination is found, simple chlorination and storage before consumption should be provided.

1. *Loading.*

For simple chlorination and storage the limiting safe degree of contamination of the underground water represented by a mean *B. coli* index should not exceed 50 per 100 cc, or a figure sufficiently lower so that the number would not exceed 400 per 100 cc for more than 5 percent of the time.

2. *Storage.*

The chlorinated water should be stored in a properly protected reservoir for a period of at least 3 hours before being delivered to the distribution system for consumption. Where necessary, baffle walls should be used to prevent short-circuiting of the water from the inlet to the outlet of the detention reservoir so that the water will remain in the reservoir for the full flow-through period of time.

3. *Additional loading.*

Where the degree of contamination exceeds that requiring simple chlorination described in section III, paragraph 1, sedimentation, filtration, and disinfection may be required. This treatment and its limitations are covered under surface water supplies.

4. *Water conditioning.*

Where underground waters are subjected to softening treatment or treatment for mineral removal (demineralization) employing various processes using chemicals in contact with the water, aeration, filtration, and similar methods, the water is exposed to possible contamination and should be chlorinated before delivery for consumption.

5. *Treated effluents.*

The treated effluents should meet the requirements of the Treasury Department *B. coli* Standard for Drinking Waters.

6. *Disinfection.*

Contamination is often found in the water from wells which have recently been constructed, even where the installation has been properly made, if care has not been taken to disinfect the well and pumping equipment thoroughly after the work is completed. Such contamination is introduced into the supply during the process of construction. Contamination may also get into a supply when the system is open for repair work, when parts of the equipment may become infected through handling or contact with foreign material. Water supplies should always be disinfected following new construction or repair work in order to remove traces of contamination which may be dangerous or which may affect the results of subsequent bacteriological examinations of the water.

The disinfection of wells and pumping equipment can usually be accomplished by introducing chlorinated lime directly into the well casing.

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